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PATENT SPECIFICATION

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COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Ignition System

We, RADIO CORPORATION OF AMERICA, a Corporation organized under the laws of the State of Delaware, United States of America, of 30, Rockefeller Plaza, City and State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement :—

This invention relates generally to ignition systems, and more particularly to an improved, transistorized ignition system.

A purpose of the invention is to provide an improved, transistorized ignition system having means for regulating the current automatically to the ignition transformer over a relatively wide range of battery voltages and wherein the time for current to reach a steady state in the ignition transformer is faster than in many prior art ignition systems.

According to the invention there is provided current regulating arrangement for an ignition system of the type wherein current from a voltage source flows through a ballast resistor, the emitter-collector path of a first transistor controlled by a pair of breaker points, and the primary winding of an ignition transformer comprising a variable impedance device connected in parallel with said ballast resistor, voltage sensing means connected to said voltage source, and biasing means connected to said variable impedance device and controlled by said voltage sensing means in a sense so that the impedance of said variable impedance device increases and decreases as the voltage of said source respectively increases and decreases.

The improved ignition system comprises means for regulating the current to the primary winding of an ignition transformer over a relatively wide range of available voltages. Current from an unidirectional source of voltage is caused to flow to the primary winding of the ignition transformer through a ballast resistor and the emitter-collector path of a transistor. The base of the transistor is biased so as to cause current to flow to the primary winding when a pair of breaker points in the emitter-base circuit of the transistor is closed. Current regulation means are provided to shunt the ballast resistor automatically with a circuit having an impedance that varies with the voltage of the voltage source, thereby tending to maintain the current through the transistor substantially constant.

The invention will now be described in connection with the accompanying drawing in which :

Fig. 1 is a schematic diagram of the transistorized ignition system ; and

Fig. 2 is a graph of operating current vs. battery voltage to explain the operation of the ignition system illustrated in Fig. 1.

Referring, now, particularly to Fig. 1 of the drawing, there is shown a transistorized ignition system 10 of the type wherein the voltage from an unidirectional voltage source, such as a battery 12, supplies the energy for producing a spark across the gap 14 of a spark plug SP. The transistorized ignition system 10 may be of the type used in an automobile wherein the voltage of the battery 12 may be rated at 12 volts, for example. The negative terminal of the battery 12 may be connected to a common connection, such as ground, and the positive terminal of the battery 12 is connected to the emitter of a PNP transistor T1 through an ignition switch 16 and a ballast resistor 18. The collector of the transistor T1 is connected to the common connection through the primary winding 20 of an ignition coil or transformer 22.

[Price 4s. 6d.]

One end of the secondary winding 24 of the ignition transformer 22 is connected to the common connection, and the other end is connected to the rotor 26 of a distributor 28. A contact 30 of the distributor 28 is shown as contacting one point 32 of the spark plug SP, another point 34 of the spark plug SP being connected to the common connection. While only one spark plug SP is shown and described herein for the sake of clarity, there is a different one for each contact of the distributor 28.

Means are provided to bias the transistor T1 into conduction when breaker points 36 and 38 are closed. To this end, the point 38 is connected to the common connection, and the point 36 is connected to the base of the transistor T1 through a resistor 40 and the primary winding 42 of transformer 44. The base of the transistor T1 is connected to the emitter of the transistor T1 through the secondary winding 46 of the transformer 44 and a resistor 48. The primary winding 20 of the transformer 22 is shunted by a capacitor 49. The rotor 26 is mechanically coupled to a rotating cam 35, as indicated by the dashed line 37, to separate (open) the normally closed breaker points 36 and 38 to fire the spark plugs SP at the proper time in the cycle.

In operation, when the breaker points 36 and 38 are closed, current flows from the positive terminal of the battery 12 to the common terminal, ground, through the series circuit comprising the closed switch 16, the ballast resistor 18, the emitter-base path of the transistor T1, the primary winding 42 of the transformer 44, and the resistor 40. The voltage produced by the magnetic flux in the primary and secondary windings 42 and 46, respectively, of the transformer 44 are additive. Current also flows from the battery 12 to the common terminal through the closed switch 16, the ballast resistor 18, the emitter-collector path of the transistor T1, and the primary winding 20 of the iginition transformer 22.

When the cam 35 separates (opens) the breaker points 36 and 38, current ceases to flow through the emitter-base circuit of the transistor T1, and the magnetic field about the primary winding 42 of the transformer 44 collapses. This action induces a voltage in the secondary winding 46 of the transformer 44 in a direction such that the voltage at the base of the transistor T1 biases this transistor in a reverse direction, causing the transistor T1 to cease conducting in a faster period of time than it would without the transformer 44.

When current through the emitter-base circuit of the transistor T1 is interrupted, current ceases to flow through the emitter-collector path of the transistor T1, interrupting current through the primary winding 20 of the transformer 22 and causing the magnetic field about the primary winding 20 to collapse. The collapsing magnetic field about the primary winding 20 causes a relatively high voltage to be induced across the secondary winding 24 of the ignition transformer 22, and current flows to the spark plug SP. In the position of the rotor 26 shown in Fig. 1, current flows from the secondary winding 24 to ground through the rotor 26, the contact 30, and the gap 14 of the spark plug SP. The back-biasing voltage produced by the secondary winding 46 of the transformer 44, when the breaker points 36 and 38 are separated, is of an amplitude and duration sufficient to hold off conduction through the transistor T1 until the spark plug SP has been fired.

The ignition system 10 thus far described operates satisfactorily as long as the voltage of the battery 12 is substantially constant. When the voltage of the battery 12 is lowered, as by the heavy load caused by starting an automobile engine or by excessively cold weather, sufficient current may not be supplied to the primary winding 20 to cause the spark plugs to be fired. Regulatory means, comprising the circuit included within the dashed polygon 50, are provided to maintain the current through the primary winding 20 of the ignition transformer 22 substantially constant over a relatively wide range of battery voltages. A regulatory resistor 52 is connected in shunt, that is, in parallel, with the ballast resistor 18 through the emitter-collector path of a PNP transistor T2. The base of the transistor T2 is connected to the common connection through a biasing resistor 54. The transistor T2 is biased to conduct fully, that is, to saturate, when the battery voltage is at or below a predetermined voltage, say, for example, 8 volts. Under these conditions, the resistance of the current path for that portion of the circuit including the emitter-collector path of the transistor T1 and the primary winding 20 of the ignition transformer 22 is relatively low because current can flow through the path provided by the ballast resistor 18, and the path provided by the regulatory resistor 52 and the relatively low impedance of the fully conducting transistor T1, both paths being in parallel with each other.

When the battery voltage is greater than a predetermined value, that is, greater than 8 volts, for example, means are provided to decrease, or even interrupt, current through the regulatory resistor 52 to provide a substantially constant current to the primary winding 20 over a wide range of battery voltages. To this end, a PNP transistor T3 has its emitter connected to the junction between the ballast resistor 18 and the regulatory resistor 52 and its collector connected to the base of the transistor T2. The

base of the switching transistor T3 is connected to the common junction 55 between two serially connected resistors 56 and 58 through a diode 60, the anode of the diode being connected to the base of the transistor T3. The resistors 56 and 58 comprise a voltage-divider that is connected in parallel with the ballast resistor 18.

When the voltage drop across the ballast resistor 18 is greater than a predetermined value, the voltage at the base of the transistor T3 is sufficient to bias the transistor T3 into conduction. This action increases the voltage across the resistor 54 and biases the transistor T2 with a positive-going voltage that increases its impedance. Thus, current through the transistor T2 decreases when the transistor T3 is switched on, and vice versa. When the voltage of the battery 12 is greater than a predetermined voltage, say 12 volts, the transistor T3 is biased fully on, and the transistor T2 is biased fully off. The impedance of the emitter-collector path of the transistor T2 varies from a minimum at saturation to a substantially infinite value at cut-off over a range of voltages across the ballast resistor 18.

The operation of the ignition system 10, including its current regulatory circuit 50, will now be explained. Let it be assumed, for example, that the battery 12 is used to start an automobile engine (not shown) of which the ignition system 10 is a part. Under this heavy load condition for the battery 12, the voltage of the battery 12, due to its internal resistance, drops to, say, 8 volts. The voltage across the resistor 56 is now insufficient to bias the transistor T3 into conduction, and the transistor T2 conducts fully. Current from the battery 12 now flows to the primary winding 20 of the ignition transformer 22 through the parallel paths provided by the ballast resistor 18 and the regulatory resistor 52, provided the breaker points 36 and 38 are closed so that the transistor T1 is conductive. Since the current path provided by the parallel resistors 18 and 52, including the impedance of the emitter-collector path of the transistor T2, is one of decreased resistance, sufficient current can flow to the primary winding 20 even though the voltage of the battery 12 is lowered under engine starting conditions.

Let it now be assumed that the automobile engine has started but that the battery 12 is cold so that the voltage available from it is only 10 volts. Under these conditions, the voltage across the ballast resistor 18, that is, the voltage across the voltage divider comprising the resistors 56 and 58 also, is great enough to bias the transistor T3 into conduction. Current through the emitter-collector path of the transistor T3 increases the voltage across the resistor 54 and applies an increased positive-going bias to the base of the transistor T2, increasing the impedance of the transistor T2 and decreasing the current through the regulatory resistor 52. Thus, as the voltage of the battery 12 increases from 8 volts to 10 volts, the impedance of the transistor T2 increases so that the current available to the primary winding 20 remains substantially constant. The current that remains substantially constant is the steady-state current, and not the current during the initial rise time of the current.

Let it now be assumed that the battery 12 is providing an output of 12 volts. Under these conditions, the transistor T3 may be turned fully on, biasing the transistor T2 fully off. Current to the primary winding 20 of the ignition transformer 22 now flows only through the ballast resistor 18, the regulatory resistor 52 being disconnected from the circuit by the cut-off transistor T2. Under the latter conditions, the impedance of the emitter-collector path of the transistor T2 is substantially infinite.

Referring, now, to the graph of Fig. 2, the change in current through the primary winding 20, that is, through the transistor T1, for different battery voltages of the battery 12 is shown. The current through the transistor T1 increases proportionally with the battery voltage until the latter is about substantially 8.5 volts. Up to this point, current through the transistor T1 is supplied through the ballast resistor 18 and through the regulatory resistor 52, the transistor T2 being fully on, that is, saturated. When the battery output voltage is between 8.5 and 12 volts, the current through the transistor T1 is substantially constant, that is, about 8 amps. During this period, current is supplied to the transistor T1 through the ballast resistor 18 and the regulatory resistor 52, the impedance of the conducting transistor T2 varying inversely with the amplitude of the battery voltage. For voltages in excess of 12 volts, the transistor T2 is switched off, and the current through the transistor T1 is supplied through the ballast resistor 18 only. During this period, the current is substantially proportional to the battery voltage.

It was found that the time for current to reach a steady state in the primary winding 20 of the ignition transformer 22 was faster when the regulatory circuit 50 was used than when it was omitted. For an ignition system 10 of the present invention, having circuit components with the following values, the time to reach a steady-state current was about one-half that for an ignition system without the regulatory circuit 50. This shortened time make it possible for multi-cylinder engines to run at very fast speeds (rpm) without output high voltage degredation because adequate current is always available in the ignition transformer to provide

a good spark at the spark plugs.

An example of an ignition system in accordance with the present invention may comprise components with the following values:

Battery 12	12 volts
Resistor 18	1 ohm
Resistor 40	3 ohms
Resistor 48	10 ohms
Resistor 52	1.5 ohms
Resistor 54	35 ohms
Resistor 56	27 ohms
Resistor 58	180 ohms
Capacitor 49	1.5 uf
Transistor T1	TA 2415
Transistor T2	2N301
Transistor T3	TA 2453
Diode 60	1N2858
Transformer 44	A bifilar wound 1:1 transformer with an inductance of about 6mh/ winding. The core is a high frequency response audio material.

The above values are merely illustrative and not to be considered in a limiting sense.

WHAT WE CLAIM IS:—

1. Current regulating arrangement for an ignition system of the type wherein current from a voltage source flows through a ballast resistor, the emitter-collector path of a first transistor controlled by a pair of breaker points, and the primary winding of an ignition transformer comprising a variable impedance device connected in parallel with said ballast resistor, voltage sensing means connected to said voltage source, and biasing means connected to said variable impedance device and controlled by said voltage sensing means in a sense so that the impedance of said variable impedance device increases and decreases as the voltage of said source respectively increases and decreases.

2. Arrangement according to Claim 1, wherein said variable impedance device comprises a second transistor and that the circuit comprising the collector-emitter path of said second transistor, with a regulatory resistor in series therewith, is connected in parallel with said ballast resistor.

3. Arrangement according to Claim 1 or 2, wherein said biasing means comprises the series arrangement of a bias resistor and the collector-emitter path of a third transistor connected across said voltage source, and a connection for applying the voltage developed across said bias resistor to the base electrode of said second transistor.

4. Arrangement according to Claim 3, wherein said voltage sensing means comprises a voltage divider connected in parallel with said ballast resistor and that the base electrode of said third transistor is connected to a predetermined point on said voltage divider.

5. Arrangement according to claim 4, wherein the connection of the base electrode of said third transistor includes a diode in series therewith.

6. Arrangement according to any one of the preceding claims, wherein means are connected to the base of the first transistor to reverse bias the transistor when current flow through the transistor is cut off.

7. Arrangement according to claim 6 wherein the means for reverse biasing the first transistor comprise a transformer whose primary winding is connected to the breaker points.

8. Current regulating arrangement for ignition systems substantially as herein described with reference to Figure 1 of the accompanying drawing.

For the Applicants,
MATTHEWS, HADDAN & CO.,
Chartered Patent Agents,
31-32 Bedford Street, London, W.C.2.

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Resistor 54	35 ohms
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Transistor T1	TA 2415
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